



The inspection and testing of existing foundations to assess their suitability for reuse

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1

Why re-use?



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2

Why re-use?



Claims:

- CO₂ footprint reduction
- Reduction of noise and dirt
- Reduction of time and cost
- Subsurface congestion



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Content



- Re-use of piles
- Re-use of a pile/raft foundation
- Make it systematic!
- Future: Re-use of superstructure elements
- Limitation: Focus on NDT



BBR REFUND



SFB 1683
Modular Reuse

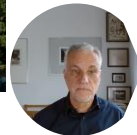
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Mast/tower foundations



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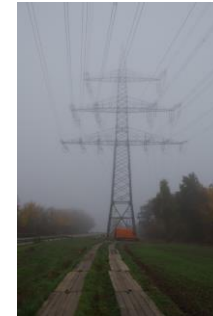
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5

Why is re-use an issue here?



- Steel lattice and tubular towers
- Overhead lines, mobile communications, etc.
- If additional loads: Re-Assessment required
- But: existing documentation not always sufficient
- Need for investigation:
 - Pole
 - **Foundation**
 - Soil



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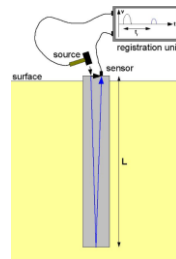
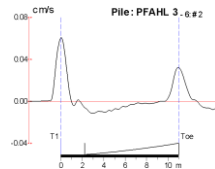
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6

Methods for determining pile length: Low-strain pile integrity testing



- Proven for QA on new piles
- May be difficult on existing piles
- Standards, recommendations: ASTM, DGGT,...



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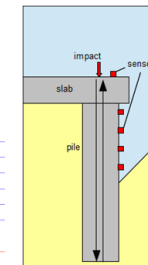
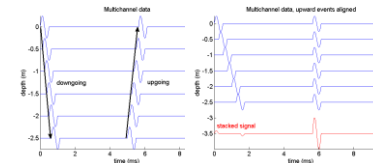
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7

Methods for determining pile length: Multi-channel method



- Extension of the low-strain method
- Speed measurement and differentiation of descending/ascending waves possible
- Niederleithinger et al., Pfahlsymposium 2015



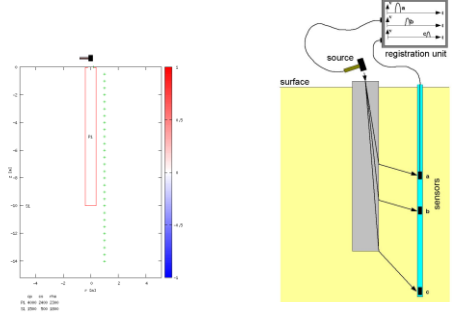
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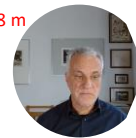
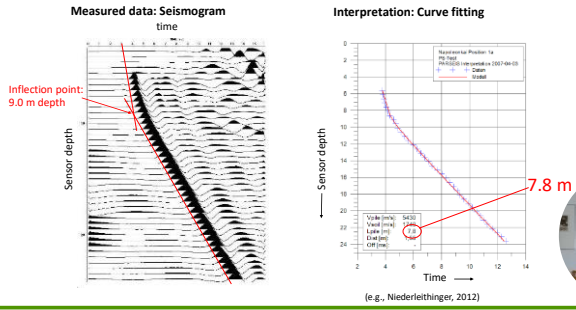
8



Methods for determining pile length:
Parallel seismic



Methods for determining pile length:
Parallel seismic



Feasibility study:
What works best?



Three locations:

- 1) Known pile foundation (the tester knows the pile length)
- 2) Known pile foundation (only the owner knows the pile length)
- 3) Pile foundation with inventory documents to be checked

Piles partly inclined, partly two piles under a beam

Three methods:

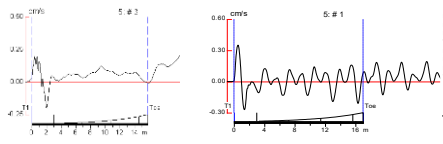
- a) Low-strain pile integrity test
- b) Multi-channel method
- c) Parallel seismics



Feasibility study:
Low-strain pile integrity testing

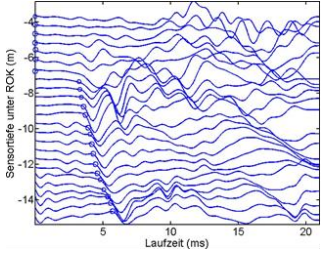


- Pile length can be determined sometimes
- In most cases, no clear results
- Same for multichannel method





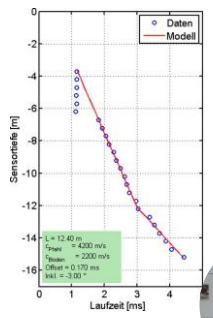
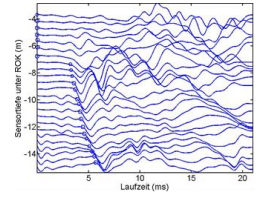
Feasibility study: Parallel Seismic



Feasibility study: Parallel Seismic



- Clear results
- Deviation at mast 2: 0.4 m (safe side)



Case study: Eight masts in southern Germany



- **Additional loads**
 - Pole reinforcement and verification of foundation required
 - Information on pile type and length available, but the latter is not clear
- **Alternatives**
 - Flat-rate replacement foundation (e.g., slab foundations)
 - Investigation with parallel seismic testing, followed by decision on a case-by-case basis



Case study: Eight masts in southern Germany



- Parallel seismic
- Drilling required for geotechnical assessment anyway
- Excitation at mast base or crossbar

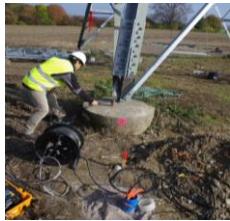




Case study: Eight masts in southern Germany

Result:

- + : Sufficient pile length in 5 cases
- : Insufficient pile length in 1 case, inconclusive results in 2 cases



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Cost analysis: Simplified! Individual case!

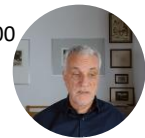
Alternative A (flat-rate replacement foundation)

- Costs for replacement foundations: 8 * €25,000.00 = **€200,000.00**

Alternative B (investigation and case-by-case decision)

- Costs for investigation with parallel seismic testing: approx. €20,000.00 (including boreholes etc.)
- Costs for replacement foundations: 3 * €25,000.00 = €75,000.00

Total: \$115,000.00 Savings: \$105,000.00



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18



Side note

Further info on Parallel Seismics:

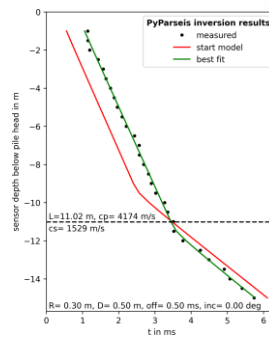
Niederleithinger, E., 2010, Dissertation U Potsdam

Niederleithinger, E., 2012, Soils and Foundation

ASTM D8381/D8381M-21

Python code:

<https://github.com/BAMresearch/PyParSeis>



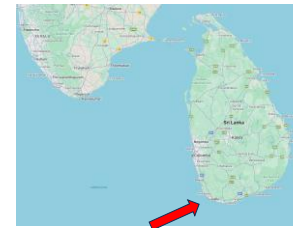
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19



Pile/raft foundation re-use: Sri Lanka example



Galle, Sri Lanka
Post Tsumani project: Maternity hospital



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20





Pile/raft foundation re-use: Sri Lanka example



2013



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21

Pile/raft foundation re-use: Sri Lanka example



2013

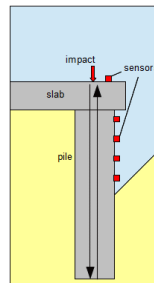


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Pile/raft foundation re-use: Sri Lanka example



Multichannel PIT
2013

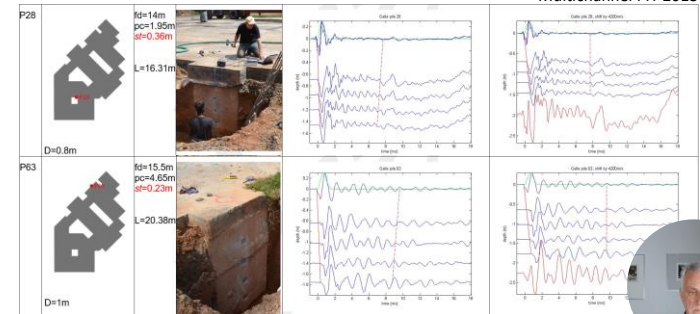


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23

Pile/raft foundation re-use: Sri Lanka example



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Pile/raft foundation re-use: Sri Lanka example



2024

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25

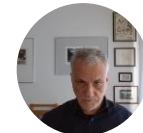
The REFUND project



- 1 research institution
- 1 university
- 2 NDT service providers
- 1 construction company
- 1 engineering firms



Guidance, flowcharts and method selection
matrices for foundation re-use



Focus on Germany

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26

The planning process

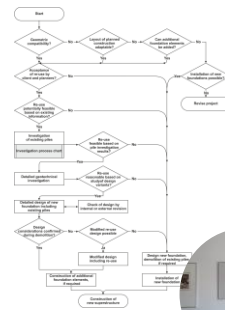


Important:

- Acceptance by planner, client, contractor
- Geometric compatibility
- Detailed check of existing files, maps, drawings, ...
- Adapt to site conditions

Separate flow charts for

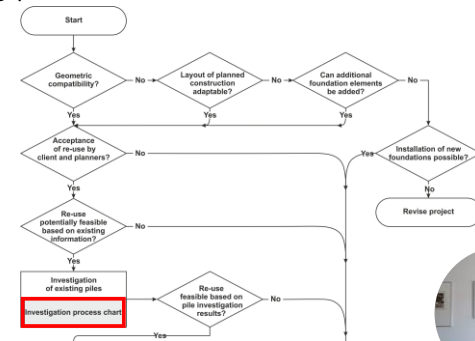
- Footings/strips
- Slabs
- Piles (presented here)



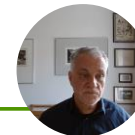
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The planning process



If still a „go“
after some thinking,
start investigation



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The investigation process



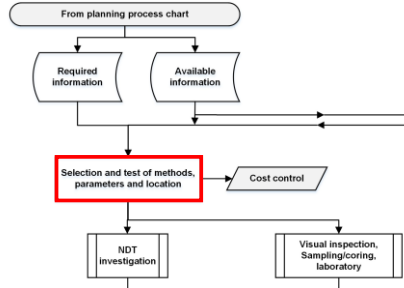
- Important:
- Select proper methods
 - Careful interpretation
 - Iterative process
- Separate flow charts for
- Footings/strips
 - Slabs
 - Piles (presented here)



The investigation process



Doing the right thing, not the cheapest, is most important



The investigation process



Task	Low-strain-integrity testing	Multichannel integrity testing	Parallel Seismic	Borehole radar	Induction method, Mise a la Masse	Visual inspection, sampling, lab. investigations
pile type			++	+	++	++
length	+	+				
diameter						++
shape			o	+		
strength	o ¹	o ¹	o ¹			o ¹
integrity	+	+	o			o ¹
concrete cover						o ¹
Applicability						
concrete piles	++	++	++	++	++	++
steel piles	++	++	++	++	++	++
wooden piles	+	+	+	+	+	++
pile walls	o	+	++	++	++	++
sheet piles	o	+	++	++	++	++
piles below structure	o	+	++	++	++	o
Remarks						
access to pile head required	yes	yes	no	no	yes ¹	yes ¹
boring required	no	no	yes ¹	yes ¹	yes ¹	yes ¹

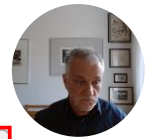
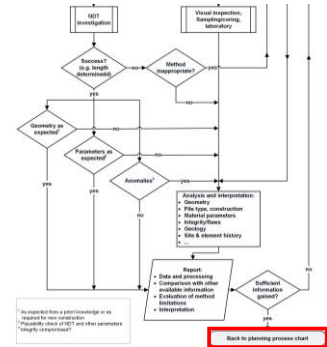
- ++ favorable
 - + applicable
 - o applicable with limitations
- 1 indirect by wave velocity assessment
 - 2 reinforced/steel part only
 - 3 accessible parts only
 - 4 using appropriate equipment at accessible parts
 - 5 access to reinforcement required for concrete piles or coring
 - 6 or coring
 - 7 geotechnical borehole parallel to pile
 - 8 coring required for sampling



The investigation process



Do your NDT and lab work, refine, interpret, report when sufficient info gathered
Then back to planning



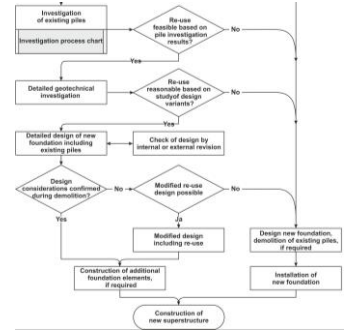


The planning process

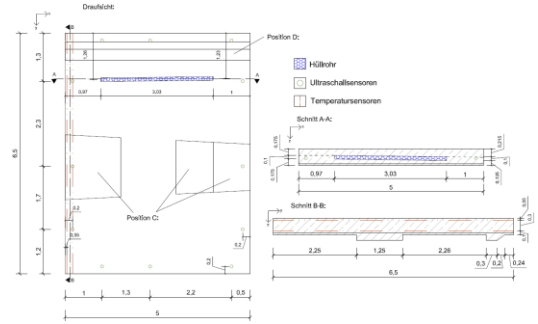


If still a „go“ after investigation, make detailed plan, calculate alternatives

If then still a „go“, start re-use!



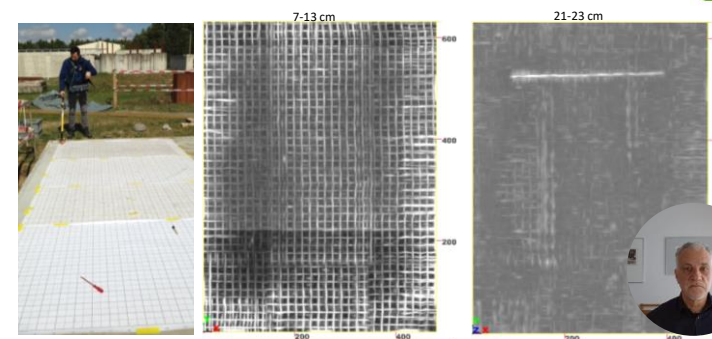
The REFUND slab



The REFUND slab

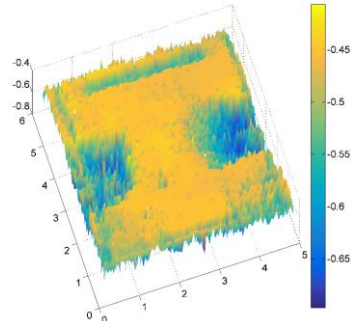
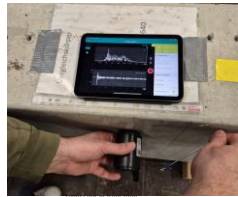


The REFUND slab: Radar





The REFUND slab: Impact Echo



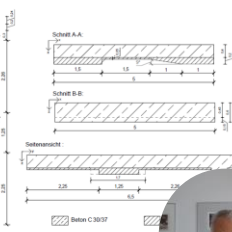
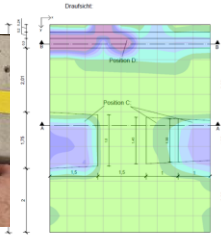
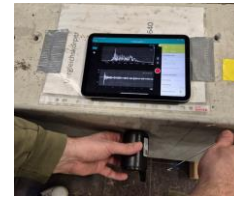
BAM, 5 cm x 5 cm

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The REFUND slab: Impact Echo



Willmes, 50 cm x 50 cm

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38

Side note



Handbuch zur Wiedernutzung von Bestandsgründungen (Handbook on the reuse of foundations)

Publisher:

Prof. Dr. Katzenbach, Dr. Ernst Niederleithinger

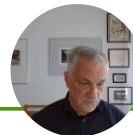
Mitteilungen des Institutes ... der TU Darmstadt, Heft 98, Dez. 2016

Partners and co-authors:

Dipl.-Ing. Michael Willmes (Implenia), Dr. Ing. Michael Schallert (GSP), Dipl.-Ing Stefan Hillmann (SKP), Dr. Jörn Gutwald and Dipl.-Ing. Henrik Ramm (TU Darmstadt), Dipl.-Geophys. Julio Galindo (BAM)

Created as part of the REFUND project

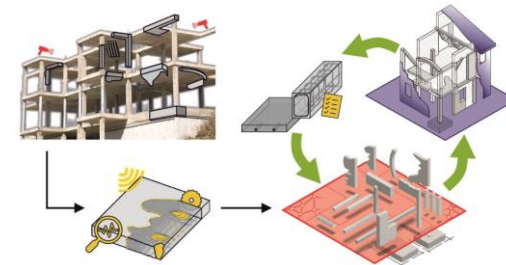
BBR "Future of Construction"



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Re-use of structural elements SFB 1683



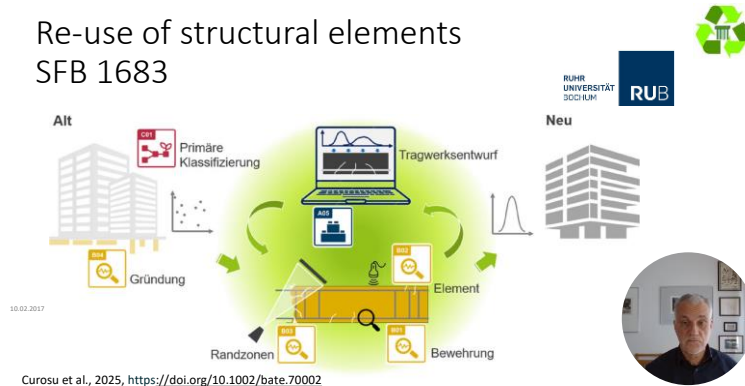
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40



Re-use of structural elements SFB 1683



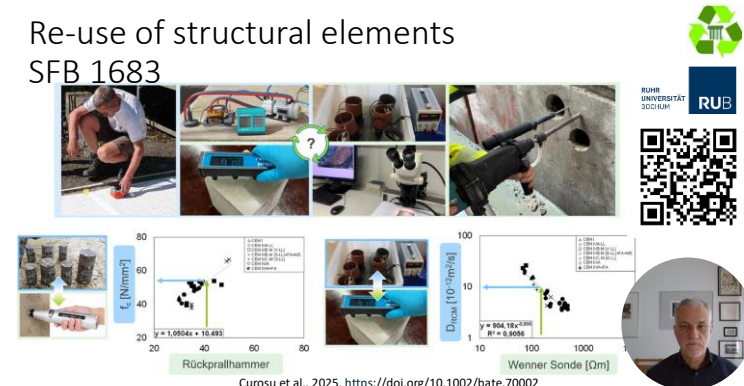
Curosu et al., 2025, <https://doi.org/10.1002/bate.70002>

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41

Re-use of structural elements SFB 1683



Curosu et al., 2025, <https://doi.org/10.1002/bate.70002>

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42

Summary and Conclusion

- Re-Use is relevant
- Re-Use is possible (with limitations and with some effort)
- No Re-Use without NDT.
- Large variety of NDT methods available
- Choice of NDT methods and proper interpretation sometimes a challenge

The To-Do list:

- Validation and reliability studies
- Automation/ML
- Translation (into information useful for the engineers)

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43

References

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- Niederleithinger, E., R. Katzenbach, S. Hillmann, M. Schallert, H. Unsel, and M. Willmes. 2019. „A Framework for Nondestructive Testing Used in Foundation Reuse Projects. ASTM INT COMM D18; Subcomm D18. <https://doi.org/10.1520/STP161120170159>.
- Curosu, Iurie, Daniel Balzani, Steffen Freitag, u. a. 2025. „Methoden Zur Bewertung Abgebauter Stahlbetonelemente Für deren Wiederverwendung“. *Bautechnik* 102 (8): 483–92. <https://doi.org/10.1002/bate.70002>.

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44



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